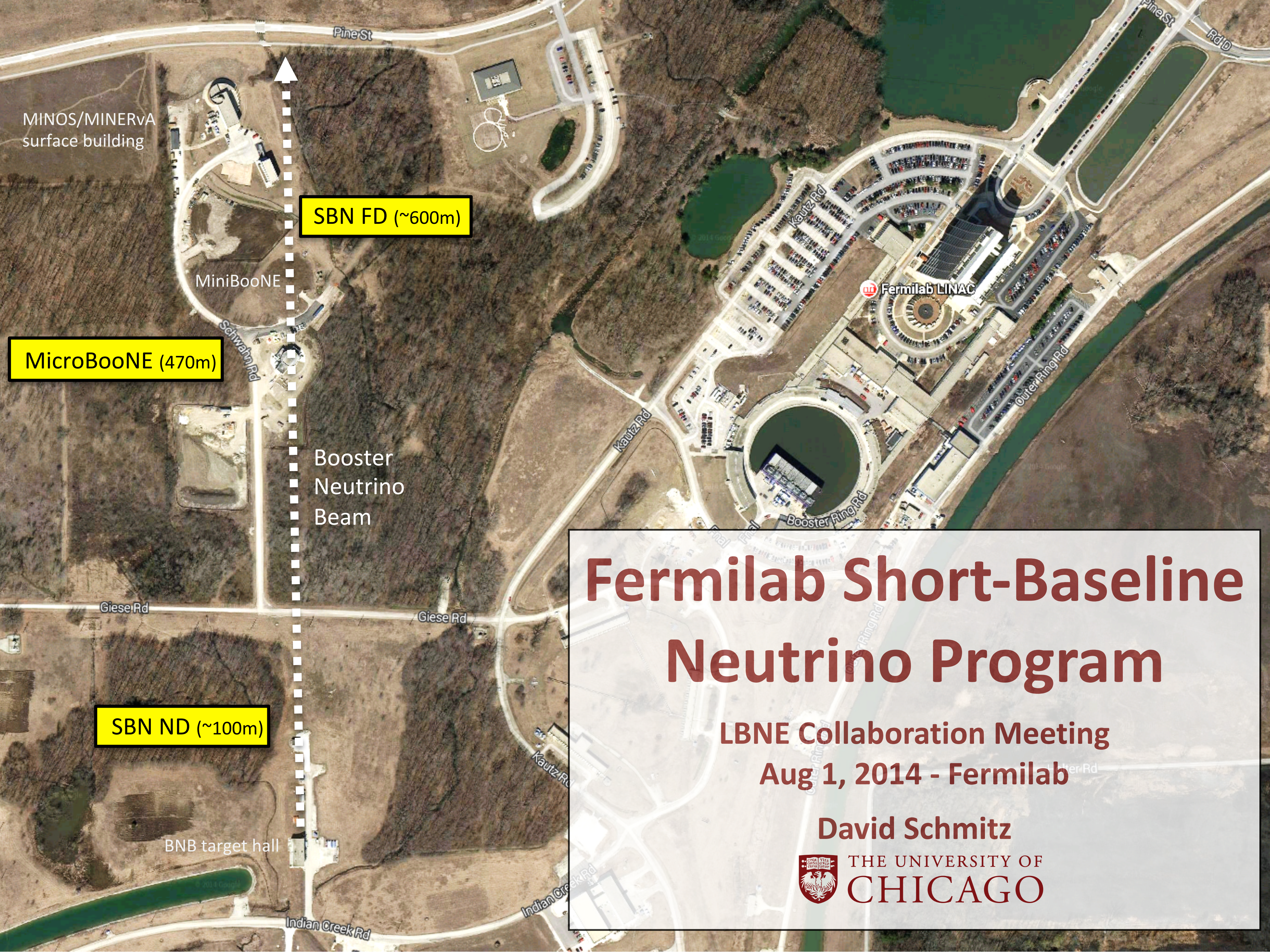


Fermilab Short-Baseline Neutrino Program

LBNE Collaboration Meeting
Aug 1, 2014 - Fermilab

David Schmitz

THE UNIVERSITY OF CHICAGO

Synergies with Long-Baseline Program, Summary

- Development and testing of detector systems toward long-baseline detectors… examples:
  - Maintain purity in fully instrumented vessels, both standard cryostat and membrane cryostat
  - Prototyping of detector systems (wire attachement & winding, light collection, laser system, DAQ/Readout, etc.)
  - Development, evaluation, and validation of cold electronics and multiplexing
  - Development and lessons learned in costing, scheduling, contracts and project management
  - Lessons learned in design, fabrication, installation, long-term operation, etc.
- Physics inputs SBN ➔ LBN
  - High statistics, precision measurements of neutrino+Ar cross sections in relevant energy ranges (BNB on-axis as well as NuMI off-axis); Important component in reaching the goal of controlling systematics at level of 1%
- Transferable analysis development
  - Development and validation of LAr calibration and reconstruction techniques; Precision testing of event reconstruction and identification with large neutrino data sets
  - Detailed systematics evaluation for sensitive oscillation measurements: $\nu_\mu \rightarrow \nu_x$ and $\nu_\mu \rightarrow \nu_e$
- Building a knowledge base with the technology and the analysis
  - The students and postdocs (and faculty) working on SBN will be faculty on LBN
- Collaboration and community
  - An active SBN program with international participation is an excellent place to develop models for effective collaboration in the near term at smaller scale
  - People want to confront data, do physics! SBN is an ideal opportunity.

Outline

- Why a Short-Baseline Neutrino (SBN) Program at Fermilab

- A little history: recent proposals to expand the SBN program, address anomalies, and search for sterile neutrinos

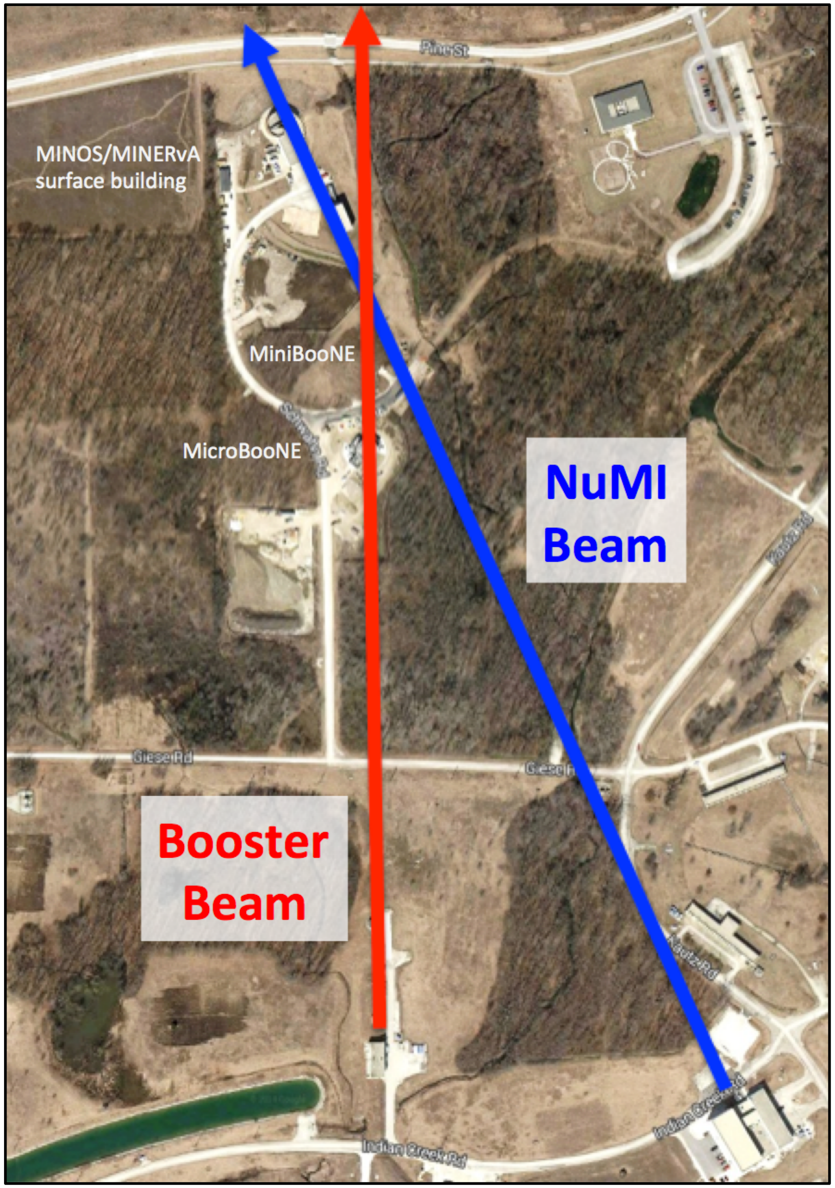
- The plan moving forward to build a world-leading accelerator-based short-baseline neutrino oscillation program on the FNAL Booster Neutrino Beam

- Synergies with an international long-baseline neutrino experimental program, LBN detectors, and LBN physics

Why a Short-Baseline Neutrino Program at FNAL

Fermilab makes an ideal host for a next generation short-baseline neutrino oscillation experimental program

- SBN Program builds upon existing capabilities and infrastructure
  - The Booster Neutrino Beam (BNB) is shallow (~10 m detector hall depth at all baselines) and neutrino fluxes are well understood due to dedicated hadron production data (the HARP experiment @ CERN) and 10+ years of study by MiniBooNE and SciBooNE
  - SBN experiments offer a great opportunity for use of mid-scale detectors which will see large neutrino exposures; continue development of the Liquid Argon TPC technology for neutrino physics.

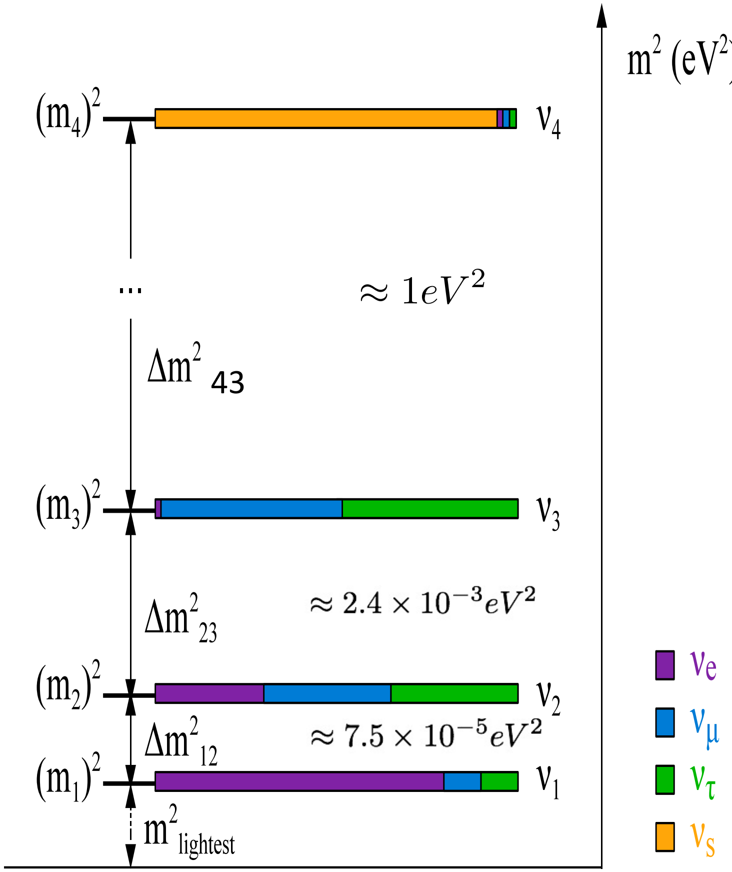


SBN Expands the Science Program

- SBN Program expands the science reach of the world-class neutrino physics program in the U.S. being hosted here at Fermilab
  - While each of the below measurements alone lack the significance to claim a discovery, together they could be hinting at important new physics

Experiment	Type	Channel	Significance
LSND	DAR	$\bar{\nu}_\mu \to \bar{\nu}_e$ CC	3.8σ
MiniBooNE	SBL accelerator	$\nu_\mu \to \nu_e$ CC	3.4σ
MiniBooNE	SBL accelerator	$\bar{\nu}_\mu \to \bar{\nu}_e$ CC	2.8σ
GALLEX/SAGE	Source - e capture	ν_e disappearance	2.8σ
Reactors	Beta-decay	$\bar{\nu}_e$ disappearance	3.0σ

K. N. Abazajian et al. "Light Sterile Neutrinos: A Whitepaper", arXiv:1204.5379 [hep-ph], (2012)



One thing is certain…

The discovery of a light sterile neutrino would be monumental for particle physics as well as cosmology

Why π Decay-In-Flight Experiments?

- There are multiple (complimentary) ways to search for evidence of sterile neutrinos (reactors, radioactive sources, DAR, etc.)
- DIF beam provides a rich oscillations program with a single facility:
  - $\nu_\mu \rightarrow \nu_e$ appearance
  - ν_μ and ν_e disappearance
  - both neutrinos and antineutrinos possible
  - CC and NC interactions
  - also cross section physics over a range of relevant energies
- Anomalies exist here (MiniBooNE neutrino and antineutrino) and these need to be addressed
- However:
  - Need detectors that can distinguish electrons from photons in order to reduce key backgrounds
  - Multiple detectors at different baselines is key for reducing systematic uncertainties

P5 Report Recommendations

Recommendation 12: In collaboration with international partners, develop a coherent short- and long-baseline neutrino program hosted at Fermilab.

Project/Activity	Scenario A	Scenario B	Scenario C	ν					
Short Baseline Neutrino Portfolio	Y	Y	Y		✓				I

Recommendation 15: Select and perform in the short term a set of small-scale short-baseline experiments that can conclusively address experimental hints of physics beyond the three-neutrino paradigm. Some of these experiments should use liquid argon to advance the technology and build the international community for LBNF at Fermilab.

MicroBooNE

❖ The first phase of the next generation SBN Program begins soon with MicroBooNE coming online later this year!

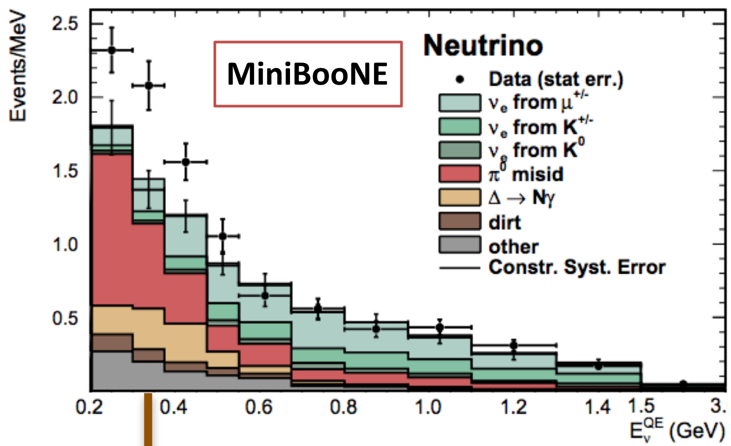
June 23, 2014

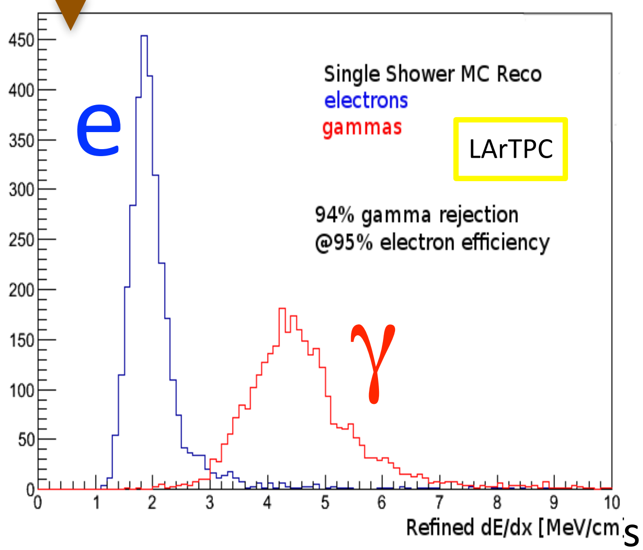
MicroBooNE

- The first phase of the next generation SBN Program begins soon with MicroBooNE coming online later this year!

- MicroBooNE already adding to crucial experience and knowledge base for design and construction of large LAr TPCs
- Operating with beam beginning early 2015
- MicroBooNE will provide valuable new data on performance of LAr detectors in a neutrino beam
    - Reconstruction development; performance of automated reconstruction and event identification tested with data
    - Complete implementation of calibrations: laser system, cosmics, both TPC & PMT detector systems
    - Physics! Neutrino-argon cross section measurements, MiniBooNE anomaly

MicroBooNE and the MiniBooNE “Low-Energy Excess”

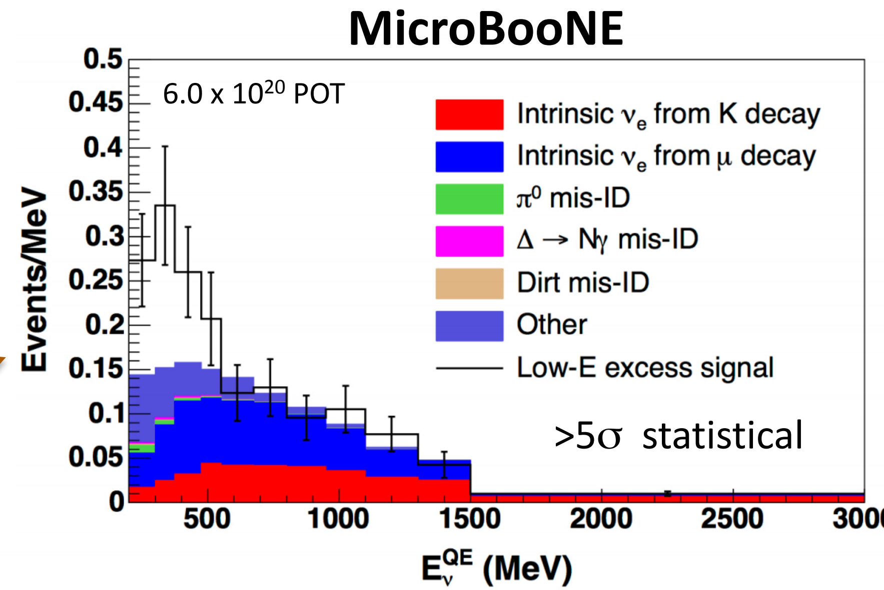


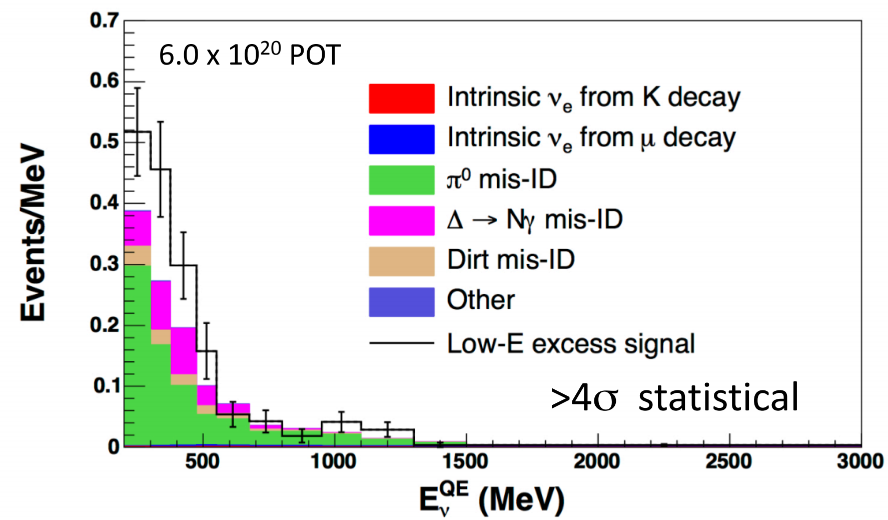


electrons

OR…?

photons





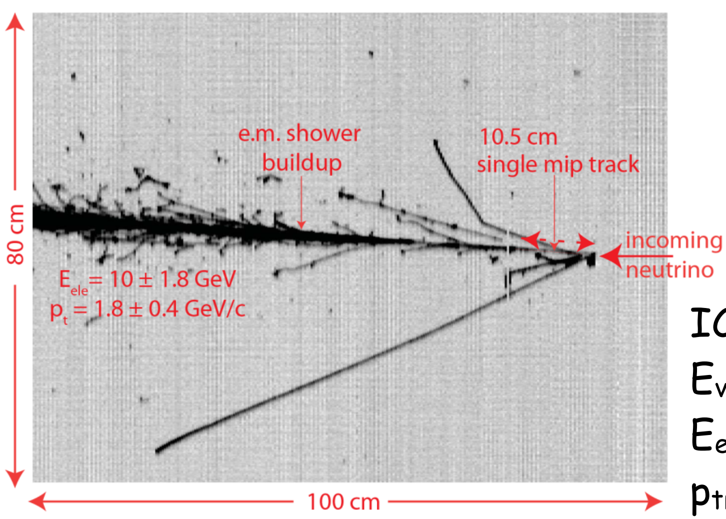
MicroBooNE can investigate a critical piece of the puzzle: **are the excess events seen by MiniBooNE electrons or photons?**

Some Recent History

- MicroBooNE, focused on understanding the MiniBooNE neutrino anomaly, was not designed to explore the complete sterile neutrino oscillation parameter space on its own
- Summer 2012, an LOI was submitted to the Fermilab PAC for the "LAr1" project. This was a 1-kton FV LArTPC, based on designs for LBNE, to serve as a second detector along with MicroBooNE. Estimated cost was $80M.
- Fast forward to the January 2014 PAC where two new proposals were put forward:
  - P-1053: LAr1-ND http://www.fnal.gov/directorate/program_planning/Jan2014PACPublic/LAr1ND_Proposal.pdf
    - Realizing the importance of a near detector to measure the unoscillated fluxes and the physics program enabled in a first phase with a ND + MicroBooNE, LAr1-ND was proposed as the next phase in the SBN program.
  - P-1052: ICARUS@FNAL http://www.fnal.gov/directorate/program_planning/Jan2014PACPublic/ICARUS.pdf
    - Was proposed to relocate an updated ICARUS T600 LArTPC detector (~450-ton FV) to the BNB and to construct a new one-fourth scale detector based on the same design to serve as a near detector for oscillation searches.

ICARUS@FNAL Proposal

- ❖ ICARUS T600 detector to be located along the BNB at ~700 m from the target
- ❖ A new T150 detector based on the ICARUS design to be located at about 150±50 m from the target
- ❖ T600 would also receive ν's from the off-axis NuMI neutrino beam peaked at ~2 GeV with an enriched ν_e flux
- ❖ The dual presence of T600 and new T150 would extend the information coming from MicroBooNE

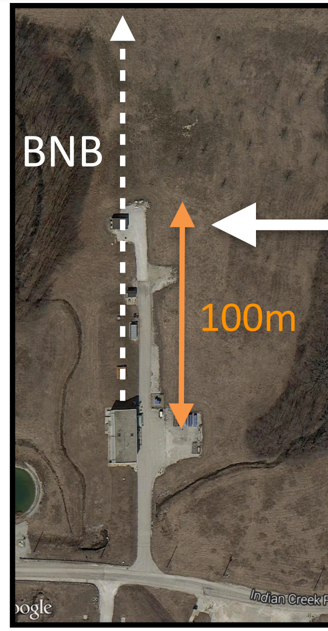


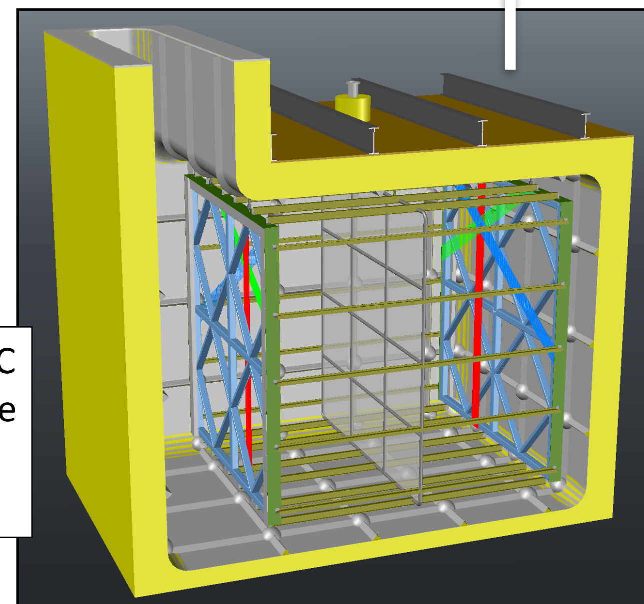
ICARUS data event with:
$E_{visible} = 11.5 \pm 1.8$ GeV
$E_{electron} = 10 \pm 1.8$ GeV
$p_{transverse} = 1.8 \pm 0.4$ GeV/c

LAr1-ND Proposal

- ❖ LAr1-ND detector design approach:
  - Utilize as many design elements developed for the LBNE Far Detector as feasible
  - Implement technology that builds upon experience from the T600, MicroBooNE and the 35-ton membrane cryostat prototype
  - Control project cost by reusing the empty SciBooNE detector hall at 100m on the BNB
- ❖ LAr1-ND would provide high-statistics measurement of the intrinsic BNB content, enabling sensitive oscillation searches in combination with downstream detectors
- ❖ Together with MicroBooNE, provide a complete interpretation of the MiniBooNE excess. Photons or electrons? Intrinsic to the beam or appearing?
- ❖ Valuable “physics R&D” such as reconstruction development and GeV ν-Ar cross sections.

Order 1M ν_μ events per year, 6,000 ν_e per year!





82 ton TPC membrane cryostat design

SBN Program Development

- Since the January PAC, proponents of the LAr1-ND and ICARUS proposals, members of the MicroBooNE collaboration, as well as representatives from Fermilab, INFN and CERN, have been working together to develop plans for a coherent SBN program on the BNB.
  - An SBN Program Coordinator (Peter Wilson, FNAL) was assigned and charged to work with contact persons from the three detectors to develop an initial cost, schedule and requirements package for a coherent short-baseline neutrino program
  - Kicked off with a three day workshop at FNAL April 30-May 2 with 25 participants from ICARUS, LAr1-ND, MicroBooNE, LBNE, NESSIE, CERN, Fermilab Engineering
  - An international Task Force* was formed to lead the preparation of an SBN proposal to go to the FNAL PAC
  - Proposal to include the physics sensitivities for a multi-LArTPC detector program with LAr1-ND near 100m, MicroBooNE at 470m, and the ICARUS T600 detector near 600m along the BNB.

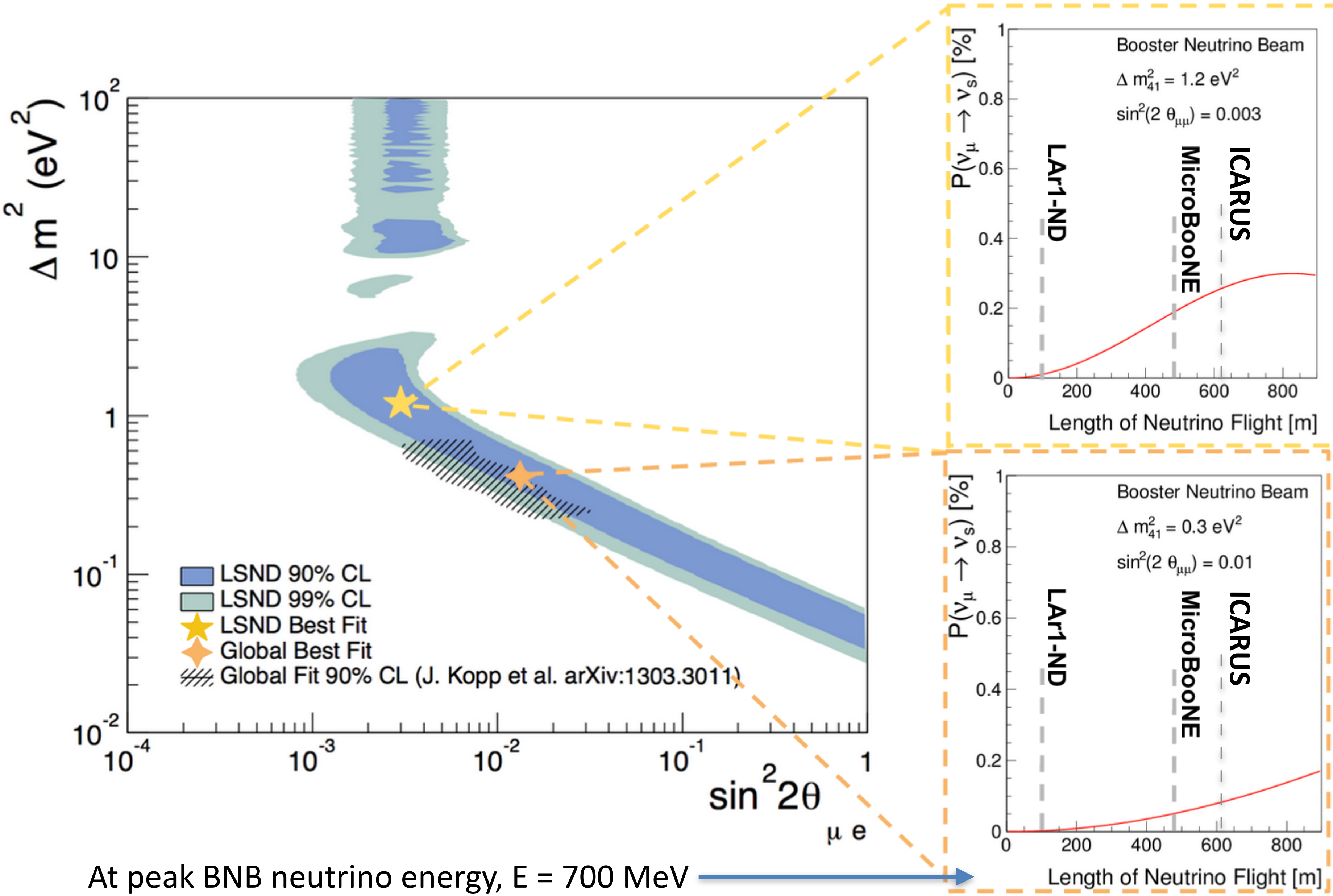
*A. Guglielmi (INFN Padova/ICARUS), M. Nessi (CERN), D. Schmitz (Chicago/LAr1-ND), G. Zeller (FNAL/MicroBooNE), and FNAL SBN Coordinator P. Wilson (FNAL SBN)

SBN Program Optimization

- Four Working Groups were formed in May, 2014 to address key issues for optimizing the experimental configuration of the SBN program; Working Groups have broad participation among the laboratories and the scientific collaborations

  1. Cosmic backgrounds
     - Impact of cosmic showers on oscillation searches
     - Mitigation strategies
  2. Neutrino Flux and Systematics
     - Optimization of ND location
     - Consider optimization of the BNB for higher flux/p.o.t.
  3. Detector Buildings and Siting
     - Building requirements
     - Costs and schedule
  4. Cryostat and Cryogenic Systems
     - Design of cryogenics including possibility of standardized systems for both detectors

Neutrino Oscillations on the BNB

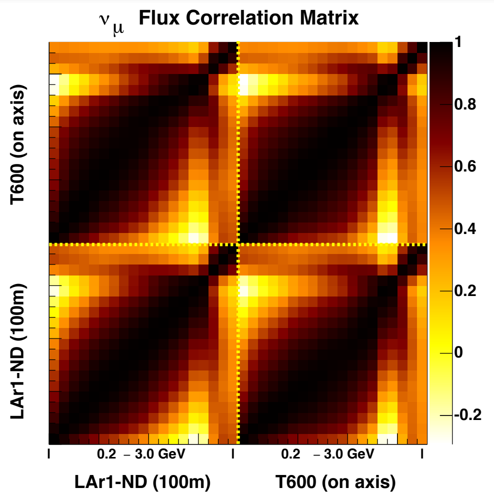


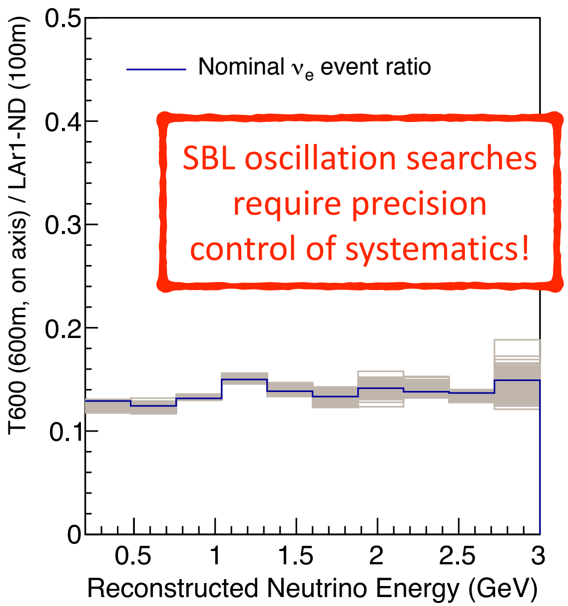
At peak BNB neutrino energy, E = 700 MeV

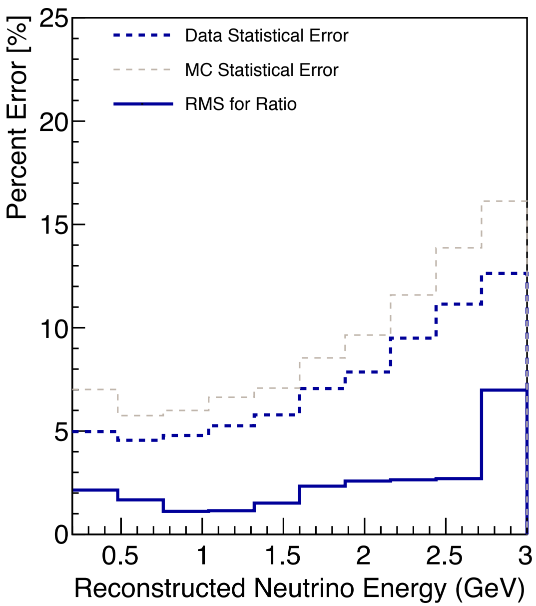
Systematics Evaluation Example: ND→FD Flux Correlations

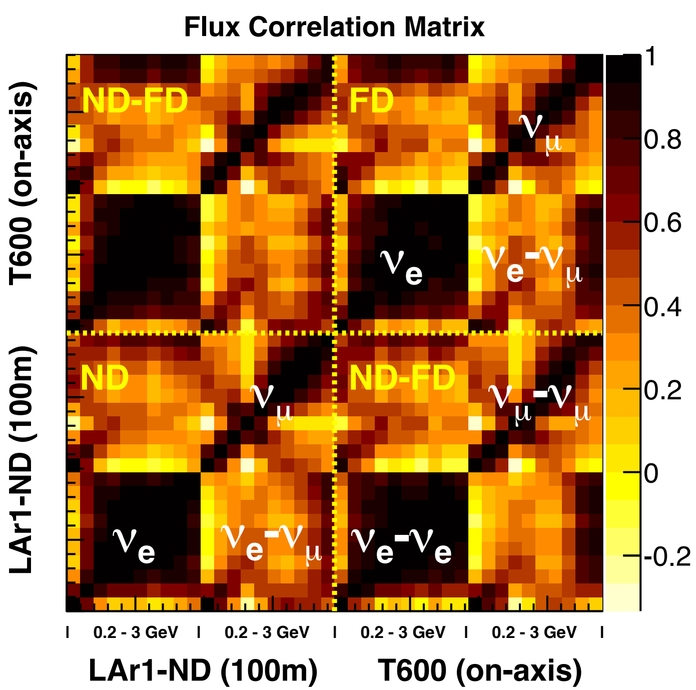
- Applied the full power of the Booster Neutrino Beam Monte Carlo developed by MiniBooNE (Phys. Rev. D79, 072002 (2009)) to a multi-detector oscillation analysis on the BNB

- Battle between systematics and lower statistics/ increased oscillation signal in more distant ND



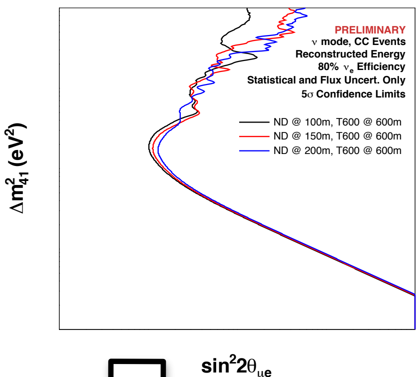




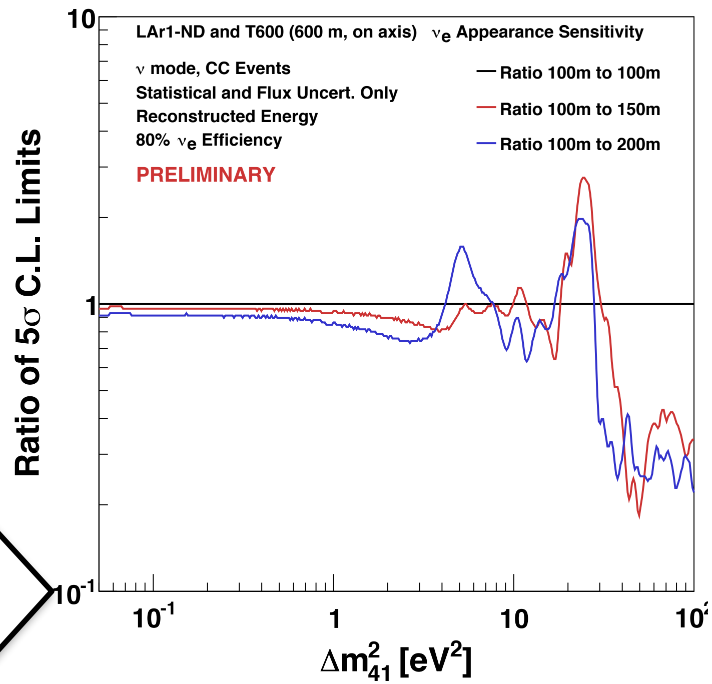


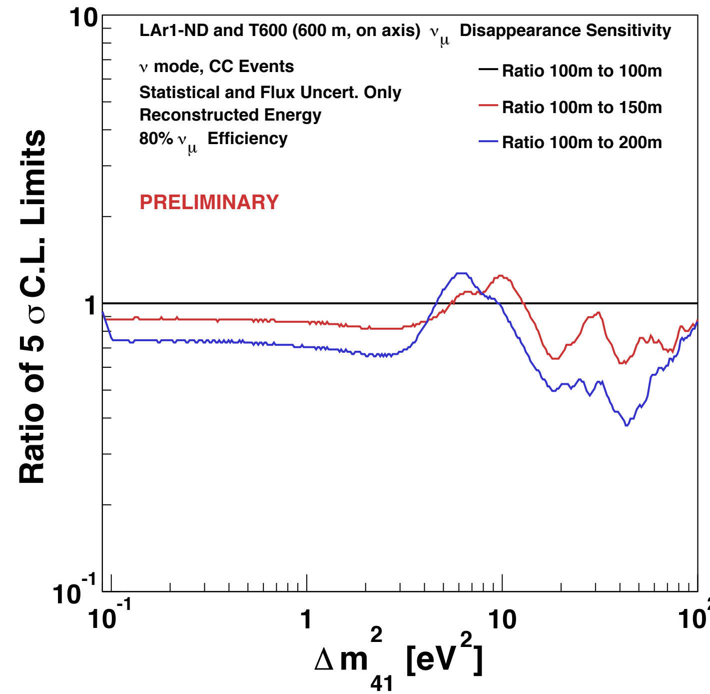
Systematics Evaluation Example: ND→FD Flux Correlations

- Both ν_e appearance and ν_μ disappearance show a small preference for the nearer location around 100m
- Cross section measurements benefit from the increased statistics as well (factor 4.4 in rate at 100m compared to 200m, for example)



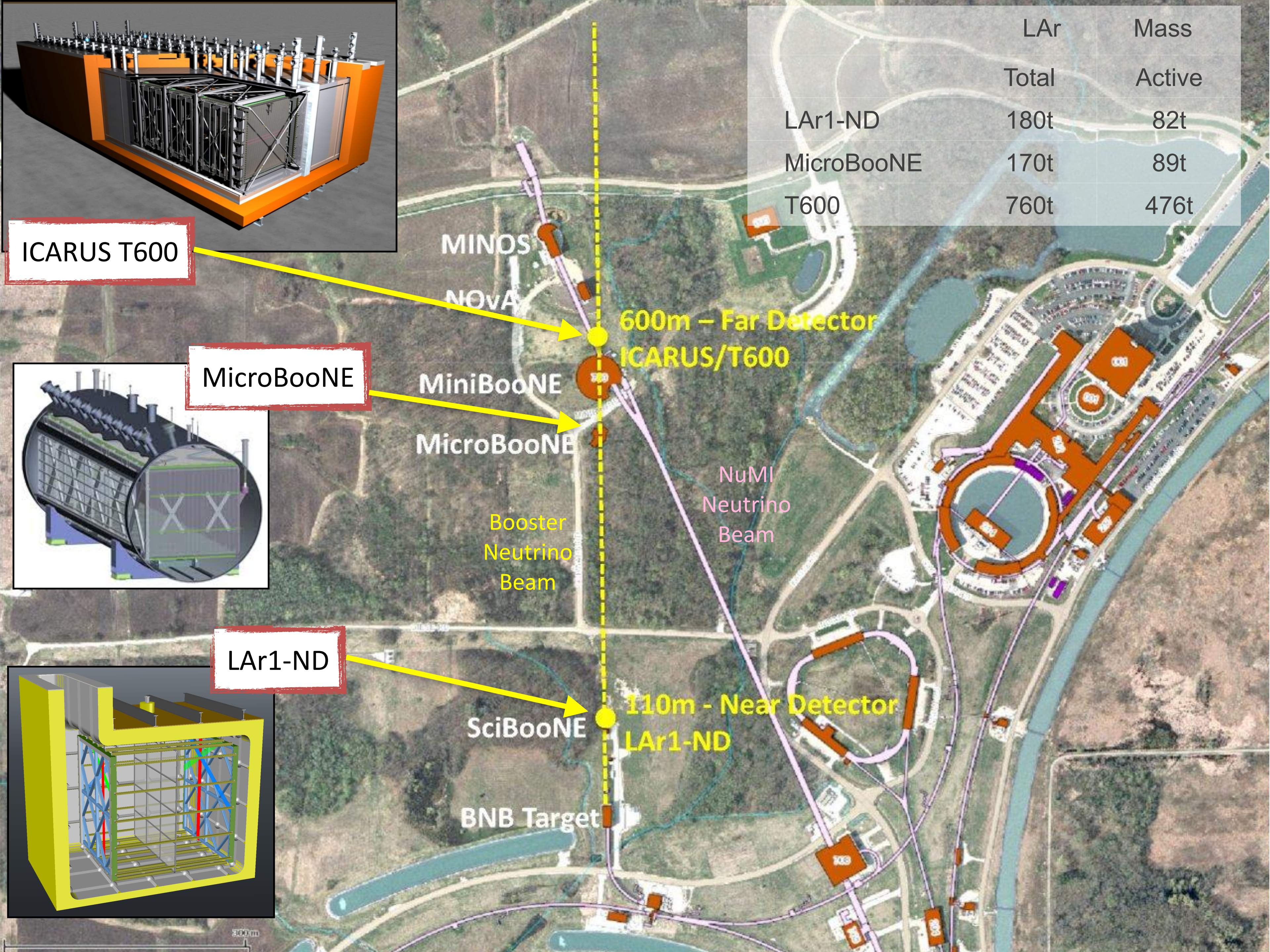
Ratio of 5σ C.L. contours





ν_e Appearance

ν_μ Disappearance



	LAr Total	Mass Active
LAr1-ND	180t	82t
MicroBooNE	170t	89t
T600	760t	476t

Collaboration Example: Cryogenics and Cryostats

Collaboration on Cryogenics and Cryostats

- A partnership is being established between CERN and Fermilab to develop infrastructure for LAr TPCs
  - Joint specifications
  - Common Designs that can be delivered to CERN, Fermilab etc
- Cryogenic systems: LAr filtration and LN2 for cooling
  - Based concept of standard skids
  - Specified jointly with detailed designs and construction contracted
  - Standardized controls
  - Test at vendor/CERN delivery to experiment
- Membrane Cryostats
  - Access to two vendors : GTT (France) or IHI (Japan)
- New engineering groups formed at CERN and Fermilab
  - Experience from ATLAS, LBNE (35ton), MicroBooNE
- SBN is first demonstration → LBN

Slide from SBN Task Force Status Report to PAC last week

Fermilab

26 Peter Wilson | Fermilab SBN Program Status and Planning 7/24/14

Development of LArTPC Detector Technology

- ICARUS T600 is the only large LArTPC operated to date and represents a wealth of knowledge in the field
- The approved WA104 R&D activity at CERN will rebuild the T600 and prepare it for beam at Fermilab

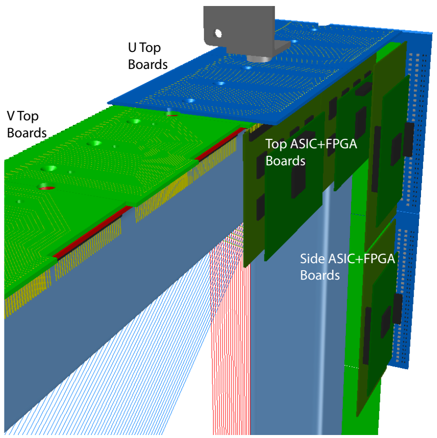
- LAr1-ND represents an opportunity to build a new LArTPC detector based on current design elements being developed for future long-baseline detectors
- The approved T-1053 (LAr1-ND) experiment at FNAL will perform needed R&D and develop the technical design for the LAr1-ND detector

- The MicroBooNE detector (E-974) will, of course, be coming online soon

- Together, the SBN Program offers a valuable and exciting opportunity for the international community who is pursuing this technology as a cornerstone in neutrino physics for the next several decades!

LAr1-ND: TPC Conceptual Layout

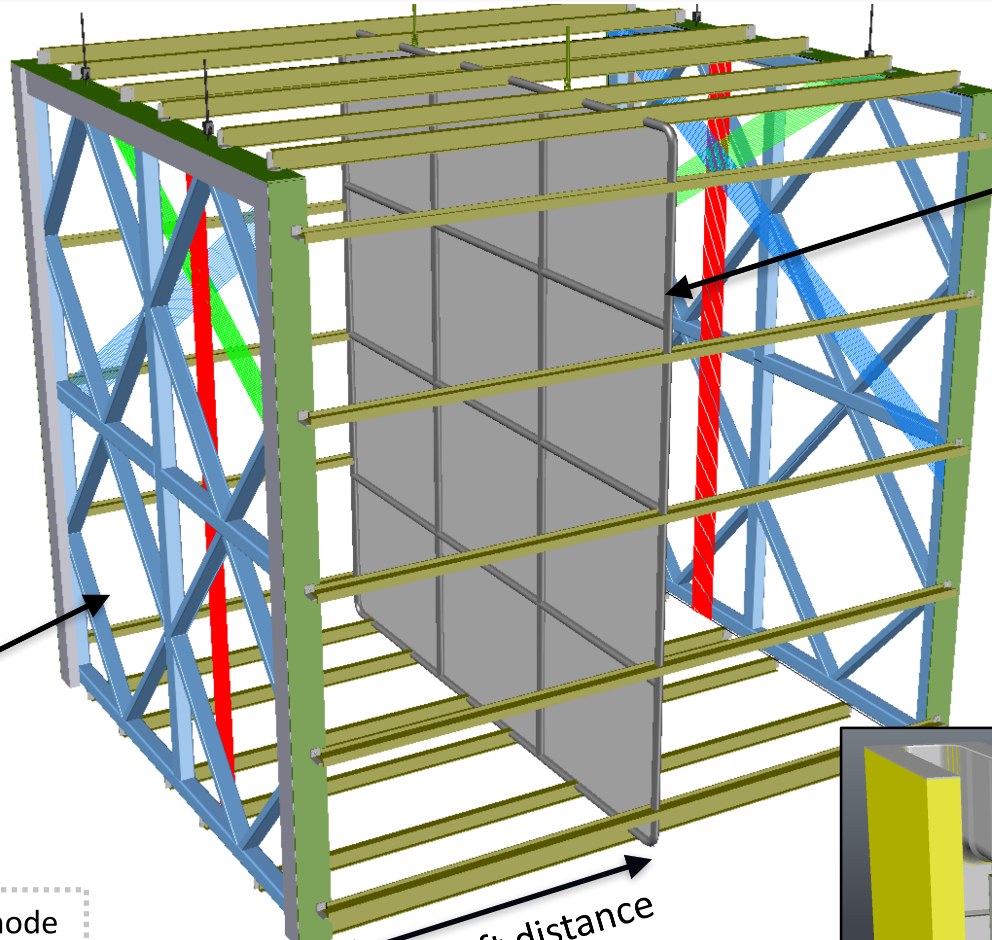
Electronics: Analog FE ASIC and ADC ASIC developed for LBNE, FPGA for multiplexing



APA

active area:
3.65 m wide x 4.0 m tall

For 500 V/cm drift field, cathode plane biased at -100 kV



CPA

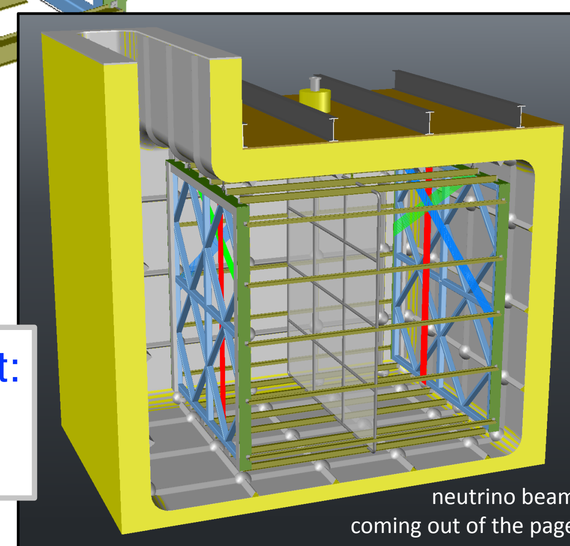
Photon system:

Small volume provides excellent test-bed for light collection systems being designed and optimized for LBNE

Open sides between each APA and the CPA are surrounded by 4 FCA (Field Cage Assemblies) modules, constructed from FR4 printed circuit panels with parallel copper strips to create a uniform drift field

Membrane cryostat:

Building off 35ton and CERN experience



Example of Building Expertise in the Community

- LAr1-ND TPC construction will be a joint US-UK university project

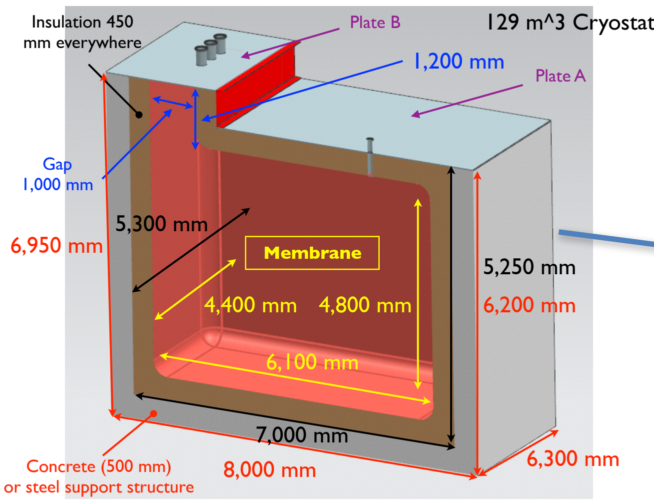
- LBNE-UK groups have long-term aim of playing a significant role in LBNE far detector construction

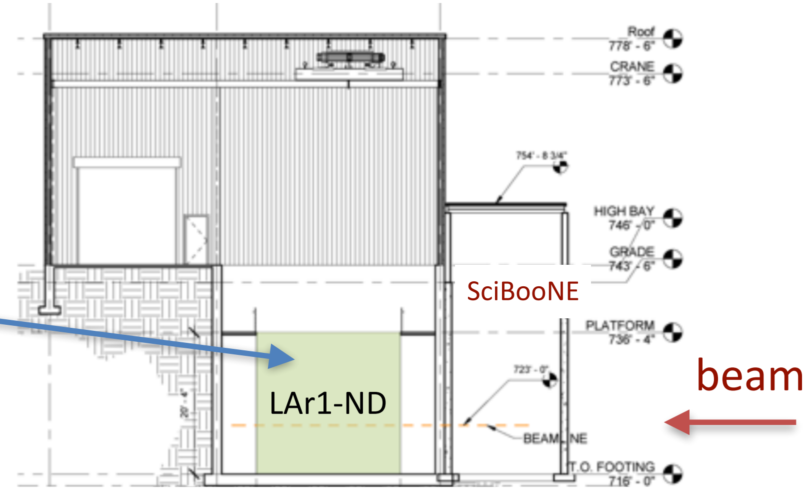
- LAr1-ND is an opportunity to apply existing expertise to a large-scale LAr construction project, build up the technical base and demonstrate capability

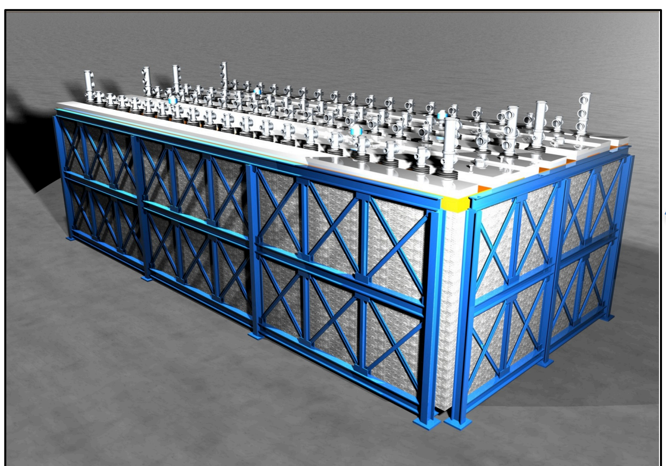
- Another example of key international collaboration and international cost sharing within the SBN program
  - NSF MRI awarded ($1.01M)
  - UK STFC proposal currently in review

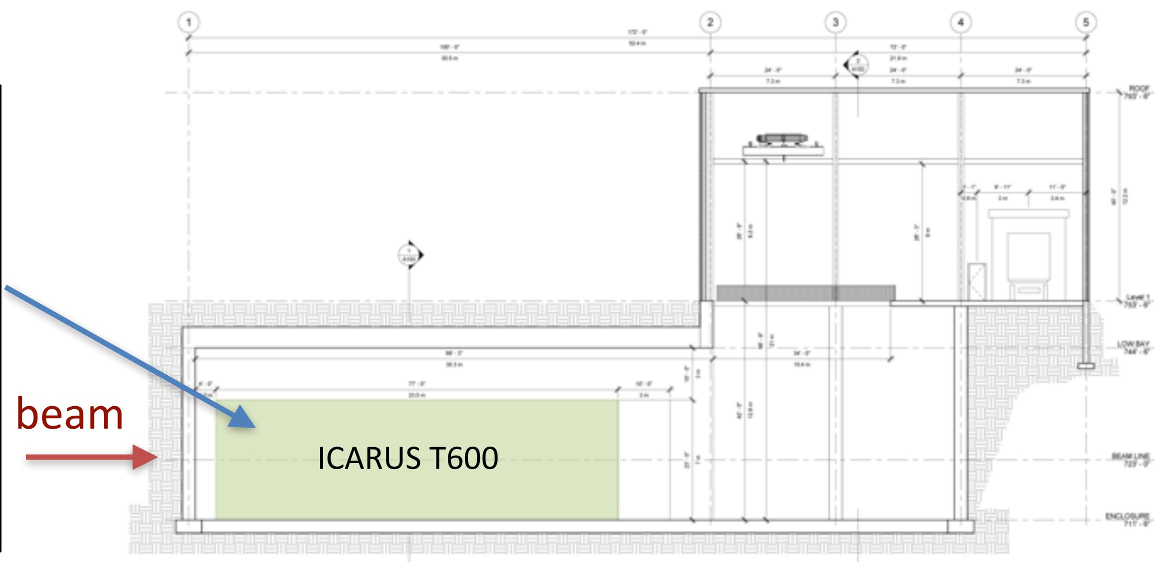
SBN Conventional Facilities

- Building requirements and design on critical path for SBN program schedule









SBN Program Schedule

Schedule and Milestones

- Goal set of having detectors ready for data taking in Spring 2018. This is very challenging but possible.
- Detailed schedule not yet prepared, presented here is a first pass at high level milestones
  - Construction of buildings is on critical path
  - Preparation of CDR must proceed immediately to define requirements of buildings and cryogenics systems
- To achieve this schedule, the work of the Task force and WGs must continue with increased participation and cooperation in the coming months

High Level Milestones

Milestone	Date
Submission of a detailed SBN proposal for peer review	Oct 2014
Final CE requirements ready final building design	Nov 2014
Near detector cryostat engineering study contracted	Nov 2014
T600 at CERN, refurbishing starting	Dec 2014
Cryogenic plants proposal submitted for peer review	Mar 2015
LAr1-ND technical proposal submitted for peer review	Mar 2015
Ground breaking for far detector building	May 2015
Cryogenics procurement plans released and active	Sep 2015
Ground breaking for near detector building	Oct 2015
LAr1-ND cryostat procurement contract issued	Dec 2015
Buildings ready, utilities installation start	Oct 2016
Start cryostat assembly for near detector at Fermilab	Oct 2016
T600 ready at CERN for transport	Nov 2016
T600 detector arrives at Fermilab	Mar 2017
Start LAr1-ND detector installation	Apr 2017
Start cryogenic plant commissioning	Aug 2017
LAr1-ND and T600 installed	Sep 2017
Start detectors cooling and commissioning	Nov 2017
Start data taking with beam	Apr 2018

Summary

- Fermilab is well positioned to play a key role in resolving the existing hints for new physics happening at short-baseline
- A discovery would be revolutionary
- SBN program additionally provides opportunities for important supporting physics measurements and detector R&D toward the future long-baseline neutrino program
- SBN program offers an ideal opportunity to build valuable expertise within the international neutrino community and exercise critical international partnerships on full-scale projects
- Such a program has been strongly endorsed by P5
- Finally, the SBN program will serve as a development platform and demonstration of extremely sensitive disappearance and appearance oscillation searches using the LAr technology… systematics will be key… and the experience will be directly transferable to LBNE in the future

Synergies with Long-Baseline Program, Summary

- Development and testing of detector systems toward long-baseline detectors… examples:
  - Maintain purity in fully instrumented vessels, both standard cryostat and membrane cryostat
  - Prototyping of detector systems (wire attachement & winding, light collection, laser system, DAQ/Readout, etc.)
  - Development, evaluation, and validation of cold electronics and multiplexing
  - Development and lessons learned in costing, scheduling, contracts and project management
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- Physics inputs SBN ➔ LBN
  - High statistics, precision measurements of neutrino+Ar cross sections in relevant energy ranges (BNB on-axis as well as NuMI off-axis); Important component in reaching the goal of controlling systematics at level of 1%
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- Building a knowledge base with the technology and the analysis
  - The students and postdocs (and faculty) working on SBN will be faculty on LBN
- Collaboration and community
  - An active SBN program with international participation is an excellent place to develop models for effective collaboration in the near term at smaller scale
  - People want to confront data, do physics! SBN is an ideal opportunity.

Overflow

LAr1-ND Collaboration

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*Spokespeople

10 US institutions
- 3 DOE National Laboratories
- 6 NSF institutions

8 European institutions
- 6 UK institutions
- 1 Swiss institution
- CERN

11 institutions also on MicroBooNE. Most also LBNE collaborators.

MicroBooNE Collaboration

MicroBooNE Collaboration + Project Team

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Saint Mary's University of Minnesota: P. Nienaber

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University of Bern, Switzerland: A. Ereditato, D. Goeldi, I. Kreslo, M. Luethi, C. Rudolf von Rohr, T. Strauss, M. Weber

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Yale University: C. Adams, E. Church, B. Fleming*, E. Gramellini, A. Hackenburg, B. Russell, A. Szelc

total team (collaboration + project):
- 3 countries
- 23 institutions
- 134 collaborators (includes project team)

* spokespeople,
\+ project manager

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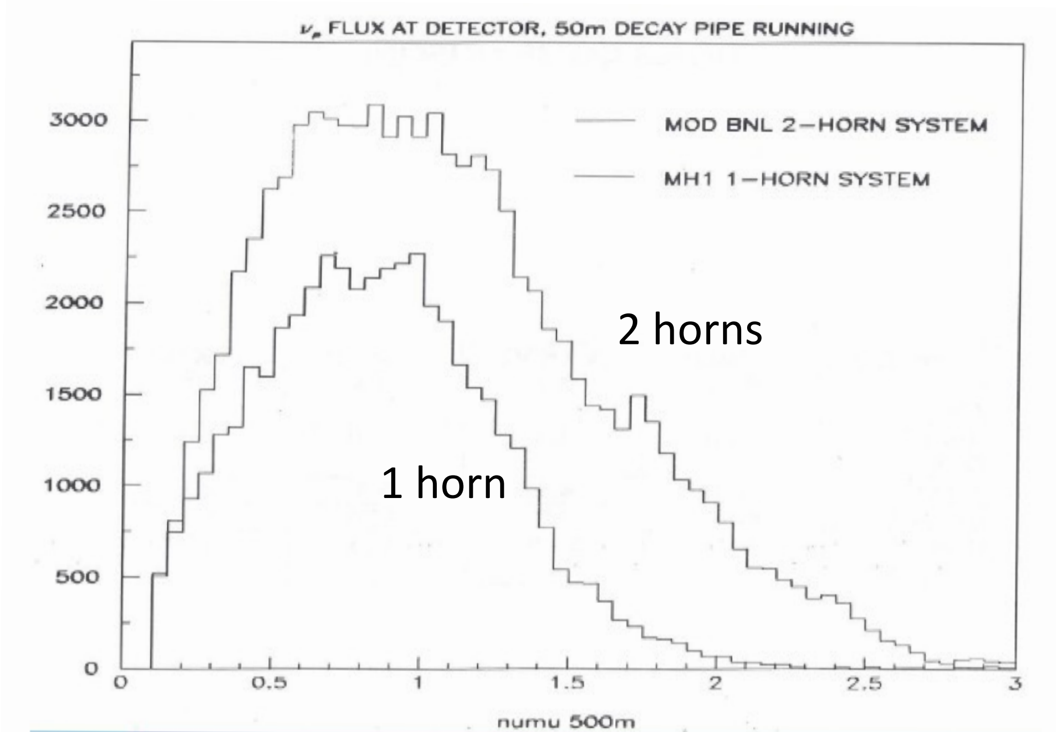
Make Every Proton Count

- Possible BNB upgrades:
  - New inner conductor design?
  - New target design?
  - Deploy 25m absorber?
  - 2nd focusing horn?



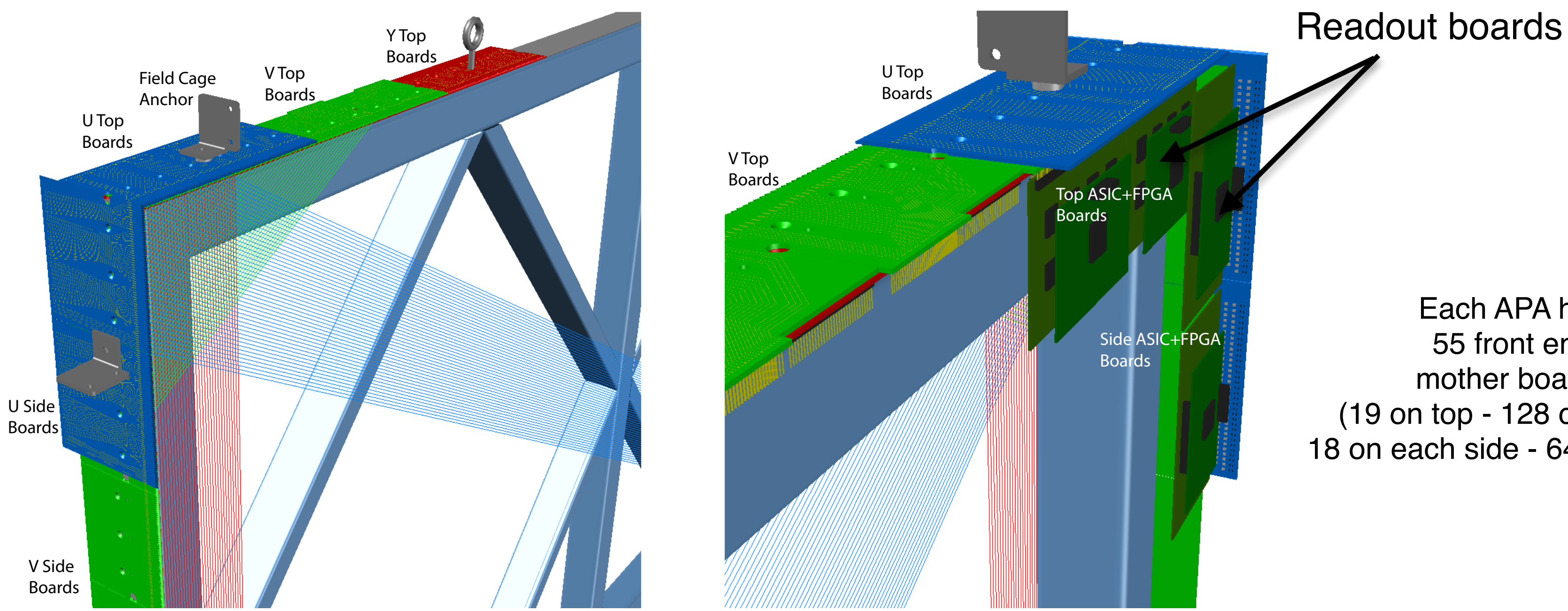
- Beamline was optimized for MiniBooNE in 1990s
  - Neutrino detector technology matters (S/B is the metric)
  - Available hadron production data (from HARP expt.) means pion production off the target now better understood. Re-optimize focusing?

LAr1-ND: Anode Plane Assemblies

Each APA holds three planes of wires on one side

- ➢ Wire pitch = 3 mm
- ➢ Wire angles = 0^0 and $\pm 60^0$ from vertical

Cold readout boards at the top and vertical sides of each APA. Total <u>4736 channels per APA</u>.



Each APA has 55 front end mother boards (19 on top - 128 channels, 18 on each side - 64 channels)

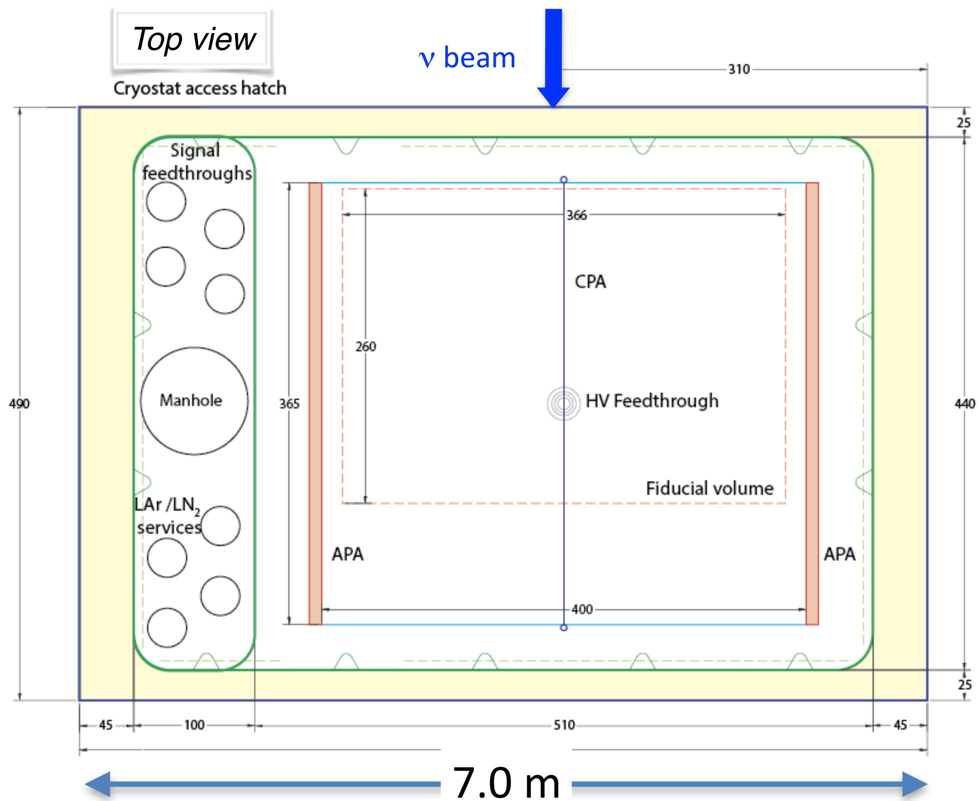
Corner view of an APA. Wires at 0^0 (collection plane) and $\pm 60^0$ from vertical (2 induction planes) are attached to wire bonding boards at the sides and ends of the APA.

LAr1-ND vs LBNE Design: TPC

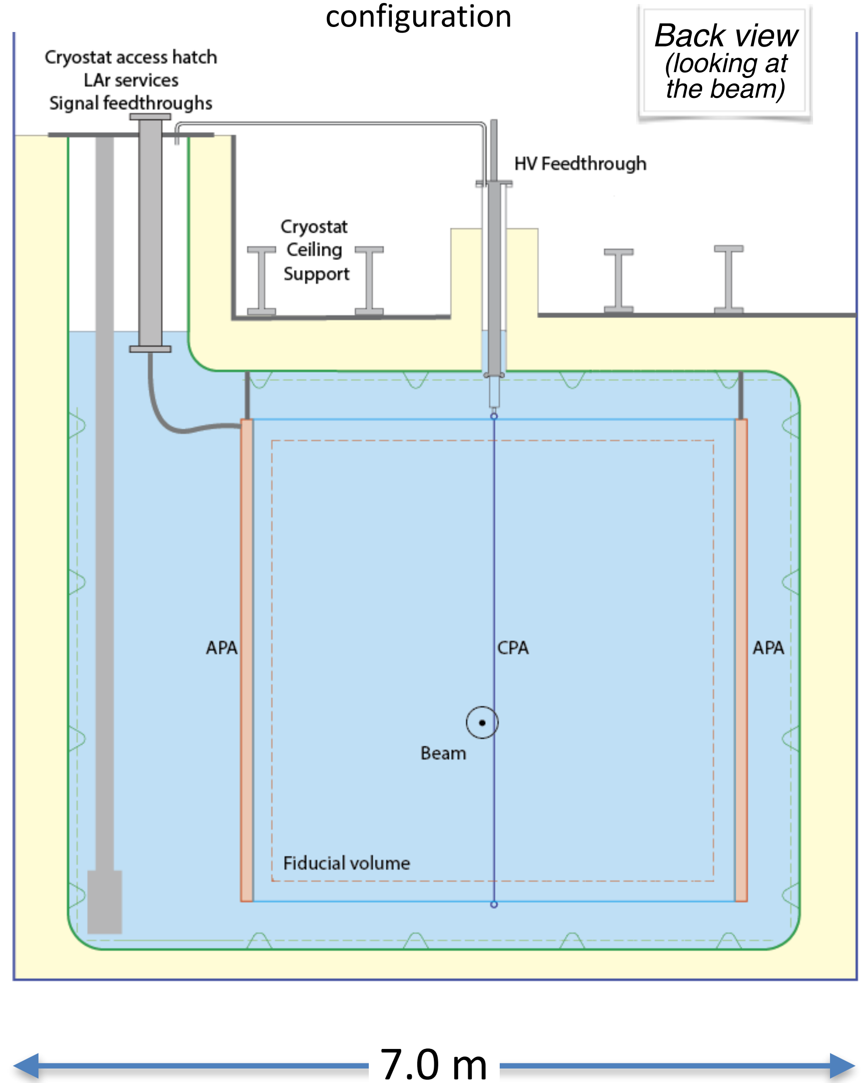
TPC	LAr1-ND	LBNE	Comparison
Construction	Pre-fabricated/tested modules assembled in cryostat	Pre-fabricated/tested modules assembled in cryostat	Same concept, different implementation
TPC Support	Suspended under cryostat roof	Suspended under cryostat roof	Same concept, different implementation
TPC configuration	CPA in the middle, single sided APAs against the walls	CPAs against the walls, double sided APAs in the middle	LAr1-ND's TPC configuration avoids a costly fiducial cut around the non-active thickness of the APA in the center of the active region. The APAs can be placed closer to the cryostat walls to maximize active region in the limited available space. For LBNE, it is cheaper to build fewer APAs if they are double sided and in the middle.
APA configuration	single sided, no helical wire wrapping, readout on 3 edges	double sided, helical wire wrapping on two induction planes, readout on one edge	LBNE's wire wrapping design allows the APAs to be tiled on 3 sides, but raised concerns about the reconstruction efficiency. LAr1-ND's APA design avoids the wire wrapping, while allowing APA tiling on all 4 sides. If the LBNE 35 ton TPC shows that the wrapped wires do not work well, the LAr1-ND design provides a verified alternative to the LBNE APAs.
APA wire configuration	3 sense wire planes, +/- 60 degree, 3mm wire pitch, identical to MicroBooNE	3 sense wire planes, +/- 45 degrees, 4.5-5mm wire pitch	LAr1-ND's wire configuration is set to be identical to MicroBooNE to avoid additional systematic errors when running together. LBNE's wire angles are supposed to be better suited for beam neutrino events. The large wire pitch is compatible with the larger diffusion over longer drift.
APA wire bonding	CuBe wires epoxied and soldered to PCB with notched edges	CuBe wires epoxied and soldered to PCB with notched edges	Same design
CPA design	stainless steel frame + conductive sheet	stainless steel frame + conductive sheet	Same design concept, light transmission TBD.
Field cage design	Cu strips on FR4 panels	Cu strips on FR4 panels	Similar design.

LAr1-ND: Membrane Cryostat

- Recent design concept shown here
- Main volume wetted on top
- LAr pump in non-active volume allows LAr circulation when necessary
- Long “cold” signal feed-throughs still an option
- High voltage FT does not pass through expansion tank



Similar to 35 ton configuration



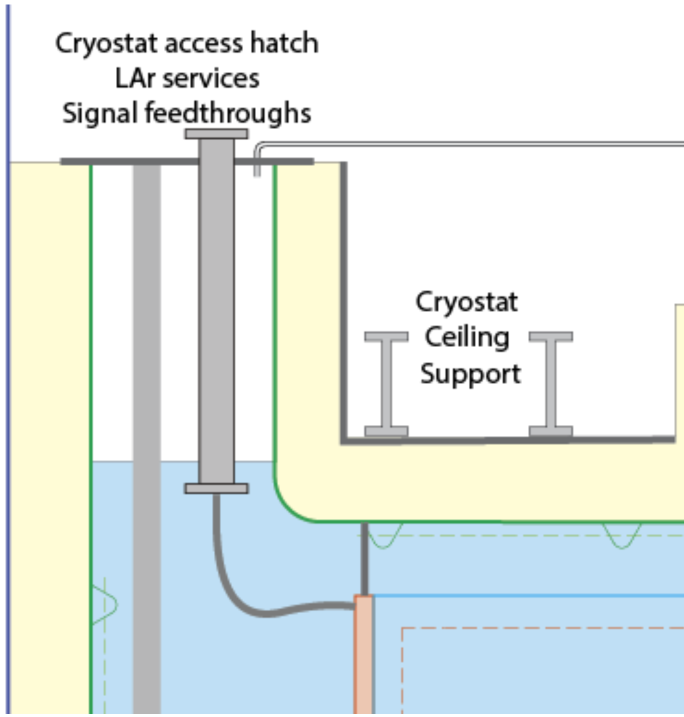
Shielding blocks removed in favor of an access region over LAr but not the active area

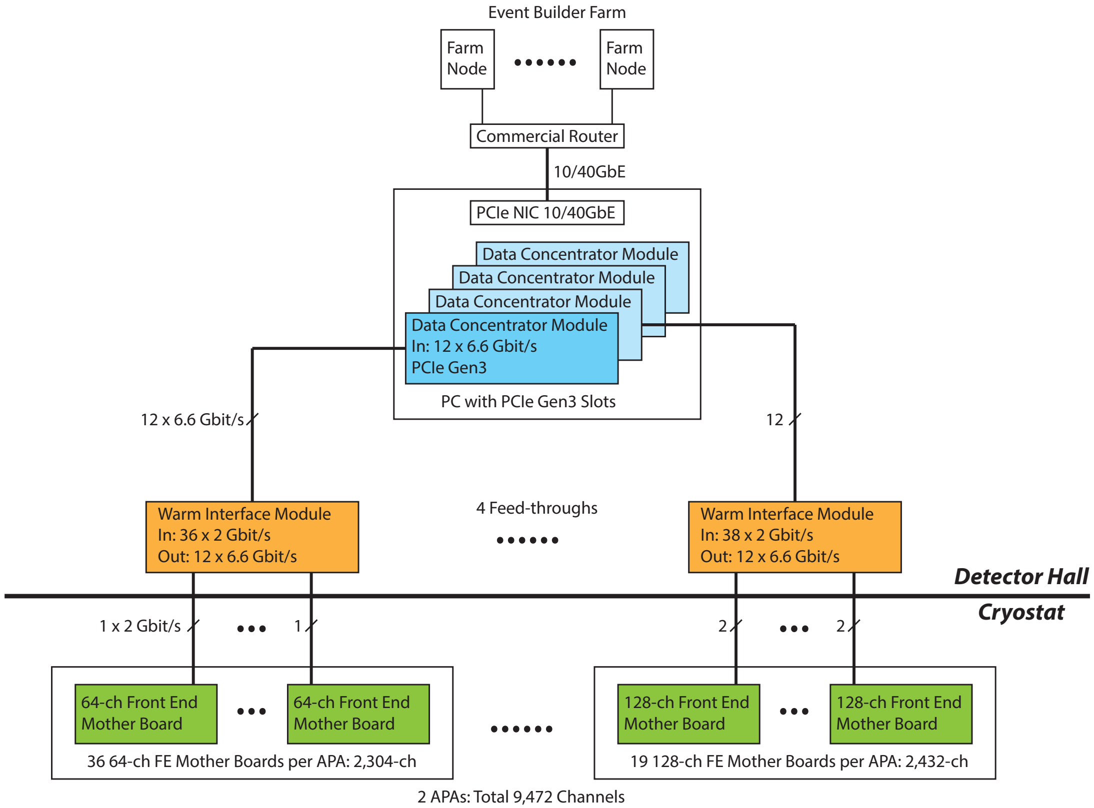
LAr1-ND vs LBNE Design: Cryostat

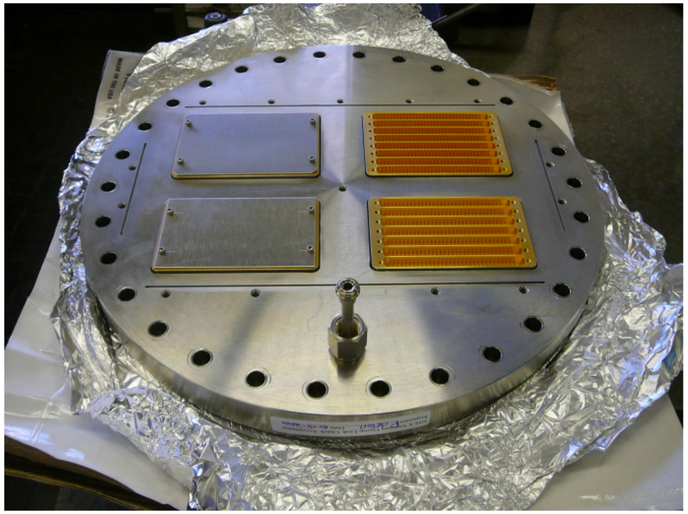
Cryostat/ Cryogenic	LAr1-ND	LBNE	Comparison
Cryostat Technology	Membrane	Membrane	Similar commercial technology using passive foam insulation
LAr pump	Inside cryostat	Inside cryostat	Similar design. May not pump LAr continuously in LAr1-ND.
Ullage space	Confined to a region over inactive region	In the cryostat	An isolated expansion region in LAr1-ND allows the main cryostat to be completely filled with LAr, eliminates outgassing from warm surfaces inside the cryostat
Purification	Dual phase during filling, gas phase thereafter	Dual phase throughout	With the warm ullage in a separate area in LAr1-ND, a much smaller scale purification system can be used in the small gas volume during the normal operation of the TPC
Cooling	Heat exchanger inside cryostat	Heat exchanger outside cryostat	LAr1-ND uses cooling panels inside the cryostat, results in better stability in LAr temperature and convection. The lower convection simplifies the prediction and correction of the positive ion distribution on a surface detector.

Signal Feed-throughs, warm Electronics & DAQ

- Considering long "cold" feed-throughs that dip into the liquid.
- Eliminates exposed cables in the gas region
- Reliability and hermetic seals are concerns
- ATLAS has developed such a FT designed for both warm and cold flanges. MicroBooNE used for warm FTs.
- External to the cryostat is the Warm Interface Module (WIM), timing system, and commodity Data Concentrator Modules (DCM), network switch and computing farm



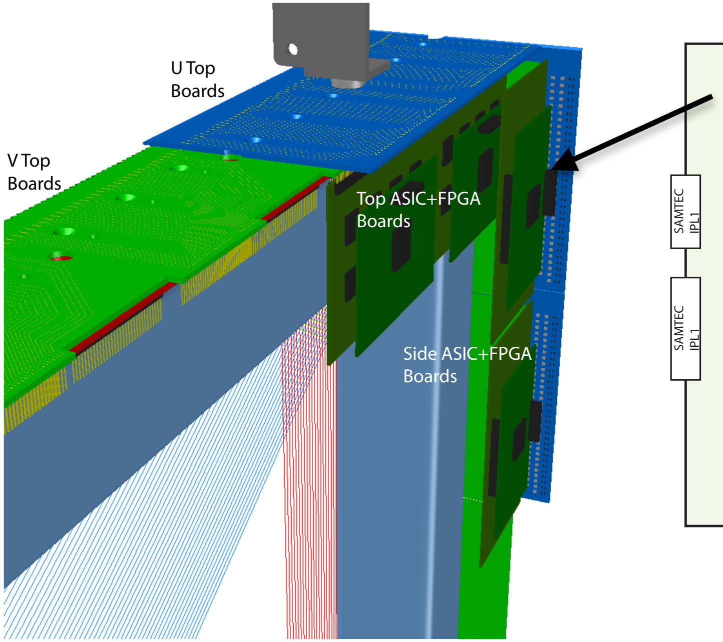


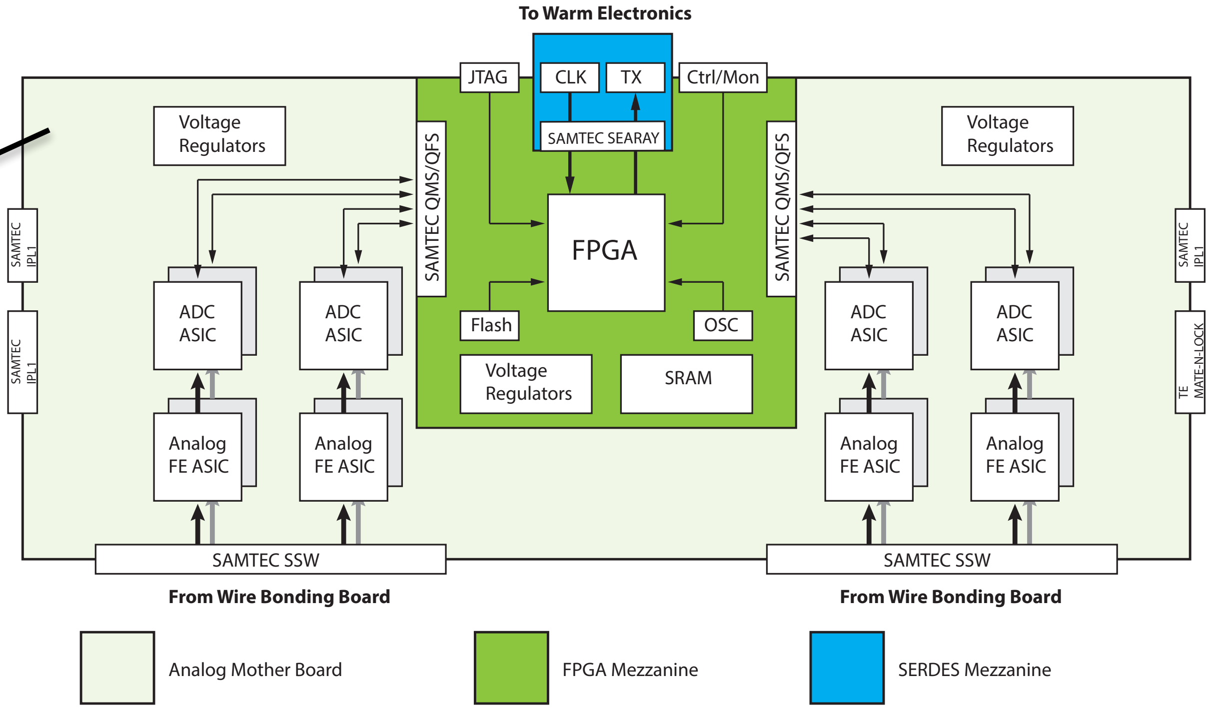


Readout Electronics

- Analog Front End ASIC and ADC ASIC have been developed for LBNE; Analog Front End ASIC is being used in MicroBooNE; Commercial FPGAs for multiplexing in the cold; similar to that used in 35 ton, with opportunity for longer term running and large data samples.

- After on-board multiplexing, 4 cold cable bundles to 4 signal feed-throughs





Front End Mother Board

LAr1-ND vs LBNE Design: Electronics

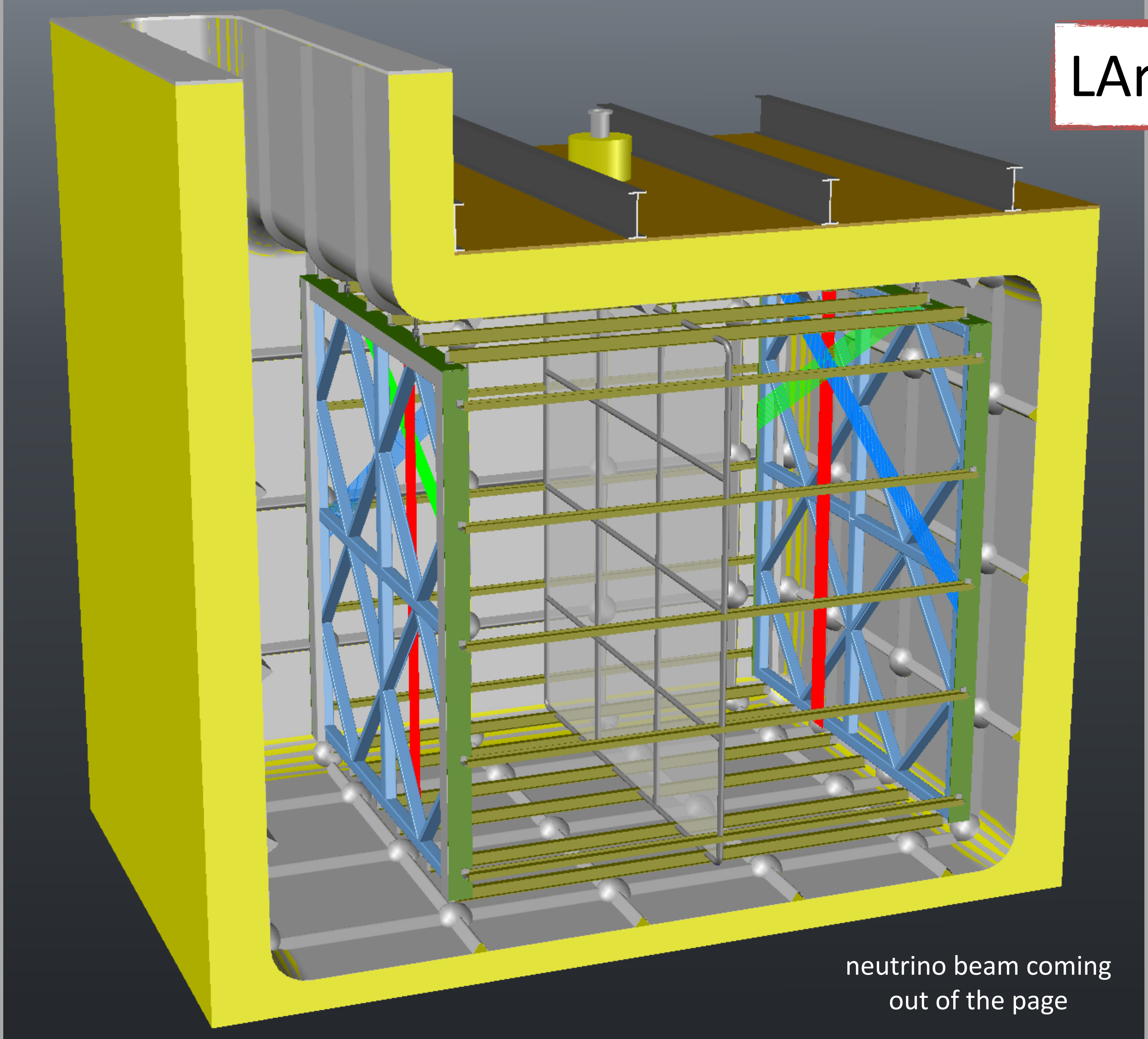
Electronics Elements	LAr1-ND	LBNE	Comparison
Analog Front-End	ASIC	ASIC	Same design
ADC	ASIC	ASIC	Same design
FE Digital Processing	FPGA	FPGA or ASIC	LAr1-ND will use FPGA to meet fast schedule; LBNE will make decision later, with inputs and experience from LAr1-ND
Front End Board	Analog Mother Board + Digital	Analog Mother Board + Digital Mezzanine	Similar design, different mechanical dimension and channel density
Cold Cable	Twinaxial Cable	Twinaxial Cable	Same design
Signal Feed-through	ATLAS Pin Carrier	Flange Board or ATLAS Pin Carrier	LAr1-ND will use already developed technology ATLAS pin carrier; LBNE will make decision later, with inputs and experience from LAr1-ND. LAr1-ND will use a double feedthrough configuration to accommodate both the cold cables inside the cryostat and the warm cables outside.
Warm Interface Board	FPGA + Optical Transceiver	Optical Transceiver and/or FPGA	LAr1-ND will use FPGA to study data compression and trigger algorithm, and keep the capability to stream all data out; LBNE will make decision later, with inputs and experience from LAr1-ND.
Data Concentrator Board	Commercial PCIe Card	SLAC RCE	LAr1-ND will use commodity hardware in DAQ system, focus efforts on algorithm, firmware and software development

LAr1-ND vs. LBNE Design: Light Collection System

- A compact light-guide-based system like what has been proposed for LBNE *(acrylic bars read out by silicon photomultipliers, SiPMs*) is the starting design concept for LAr1-ND.

Photodetection System	**LAr1-ND**	**LBNE**	**Comparison**
Construction	Extruded light guides coated with wavelength-shifter assembled into "paddles" inserted behind APAs	Extruded light guides coated with wavelength-shifter assembled into "paddles" inserted between APAs	Same design
Photodetector	SiPM	SiPM	Same design

- However, the relatively small volume of LAr1-ND provides an excellent test-bed for light collection systems being designed and optimized for LBNE as well as for studies of the light collection efficiency as a function of photocathode coverage


LAr1-ND
neutrino beam coming
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